

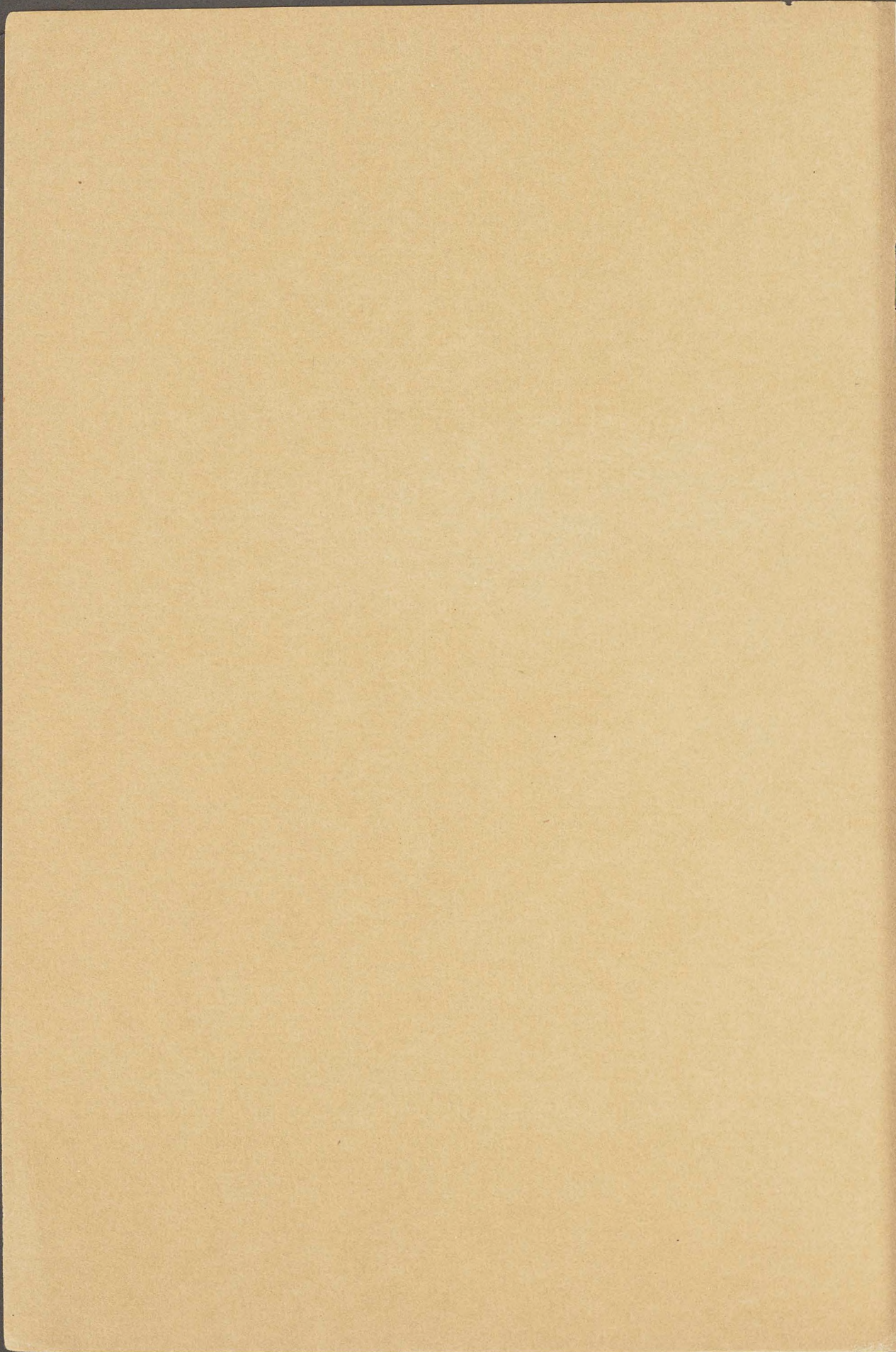
# Radium—The Supreme Marvel of Nature's Storehouse

By

G. F. KUNZ and G. FAILLA

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# Radium—The Supreme Marvel of Nature's Storehouse

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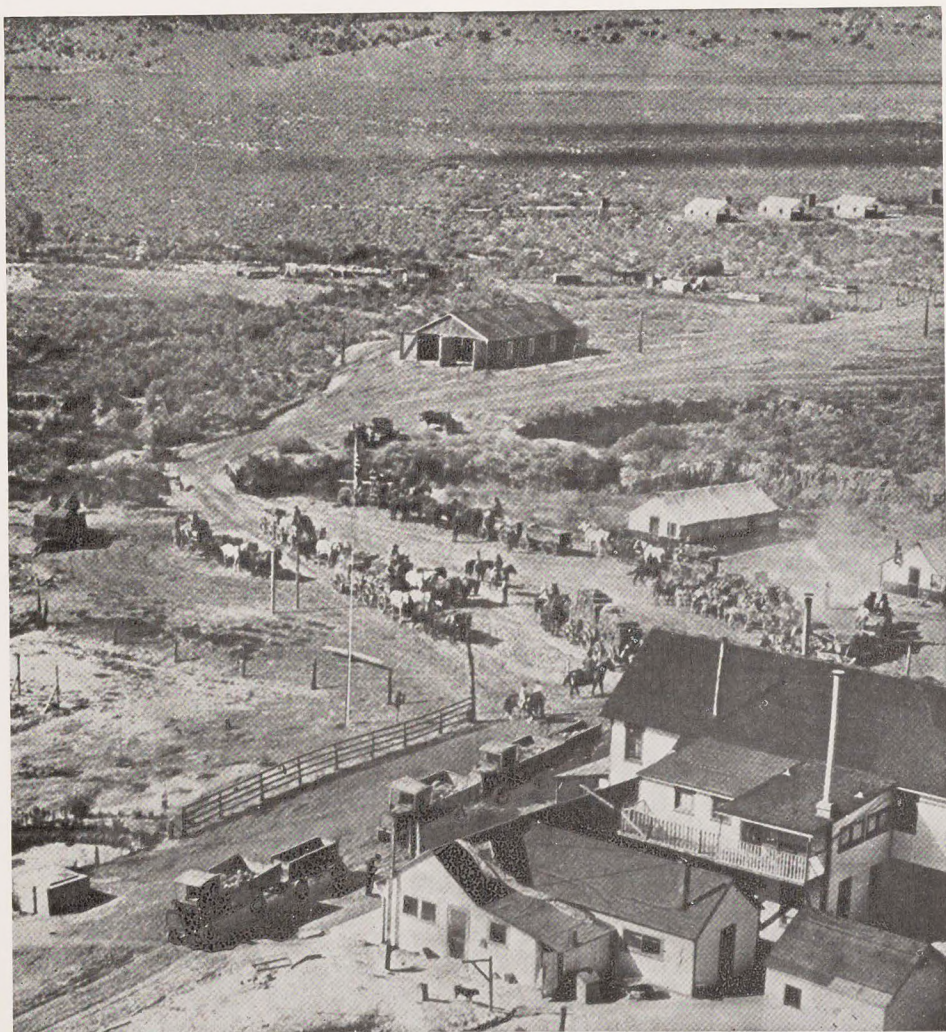
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ROCKS OF MEX

[Reprinted from NATURAL HISTORY, Vol. XXI, No. 5, pp. 520-536, 1921]

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*Courtesy of the Standard Chemical Company of Pittsburgh*

#### A DISTRIBUTING CENTER FOR RADIUM ORE

Many are the modes of transportation employed in bringing to the refining plant the hundreds of tons of ore required for the production of a single gram of radium. First the ore is gathered in the mountains and borne on the backs of burros and mules over the rough trails to the mill. Thence the concentrated ore is carried in wagons and motor truck trains to the railroad, and finally there is the long transcontinental journey from Colorado to the refining plant in Pennsylvania



# RADIUM—THE SUPREME MARVEL OF NATURE'S STOREHOUSE

AN ACCOUNT OF THE RECENT EXHIBIT AT THE AMERICAN MUSEUM, OF THIS ENIGMATICAL SUBSTANCE AND ITS USES

BY

G. F. KUNZ AND G. FAILLA

IN HONOR of the visit to this country of Madame Curie there was on view for several months at the American Museum a comprehensive radium exhibit, which in a graphic way made clear to the layman the ores from which radium is obtained, the methods applied in extracting and testing it, and the uses made of this most wonderful of substances. The collection of minerals containing radium and thorium was the most complete that has ever been shown at one time. Many specimens were taken from the splendid Morgan collection belonging to the American Museum, and others were loaned by members of the New York Mineralogical Club. The minerals occupied two large cases and were carefully arranged. There were some very rare and even unique specimens. The beautiful large crystals especially attracted Madame Curie's attention when she visited the Museum.<sup>1</sup>

In the collection there were several specimens of pitchblende from Joachimsthal, Bohemia, the ore from which radium was first extracted. The ore, however, which today supplies most of the radium produced is carnotite, named after Marie Adolph Carnot, Director of the École des Mines of Paris, and brother of the late President of the French Republic. It was he who first analyzed carnotite in 1899.<sup>2</sup> The chief sources of supply of carnotite ore are found in

southwestern Colorado and southeastern Utah. The ore occurs rather plentifully, but its radium content is much lower than that of pitchblende. Ores rich in carnotite have a canary-yellow color. In general the carnotite forms part of the cementing substance between sand grains, so that a very large quantity of material has to be handled in the process of concentration.

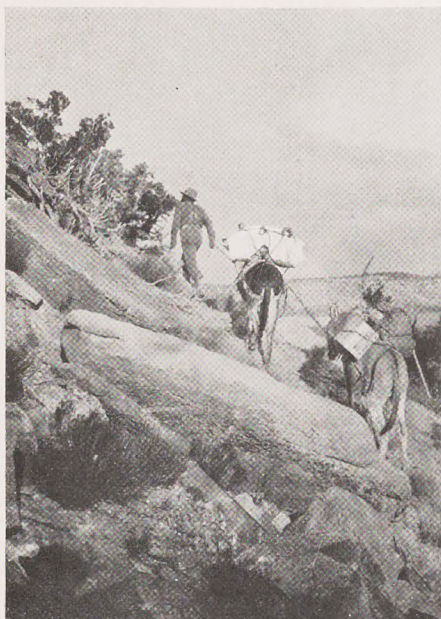
A very interesting specimen of carnotite was kindly loaned by the Radium Company of Colorado. It is probably the humerus of one of the Sauropoda or amphibious dinosaurs, of the genus *Morosaurus* from the Morrison Formation or an equivalent, which would bring it at the dividing line between the Jurassic and Cretaceous periods. The infiltration of carnotite can be seen clearly at one end of the bone from which a small piece has been broken off. The other end still shows the bone structure. The dinosaur bone was found in the Paradox Valley, Colorado.

It has been estimated that since 1911, when the first uranium radium-bearing minerals were mined in this country for radium, ore carrying 186.5 grams has been mined and shipped to reduction plants. From this ore about 125 grams of radium have been extracted in this country. Some of the ore was sent abroad before the World War and from this probably not more than 10 grams were extracted. The remainder of the radium which the ore contained may be regarded as lost because of the imperfect methods of extraction that at first prevailed, some plants not being able to secure more than 50 per cent of the radium in the ore. It is further estimated that about 25 per cent of the radium so

<sup>1</sup>It is worthy of remark that Madame Curie has expressed herself to be very anxious to obtain radium minerals which contain no thorium, and thorium minerals which contain no radium, so that she may carry still further her studies in radioactivity.

<sup>2</sup>Marie Adolph Carnot (born January 27, 1839; died in Paris, June 21, 1920) was an Académicien Libre of the Académie des Sciences, elected in 1895. He was a commander of the Légion d'Honneur. Carnotite was first described by C. Friedel and E. Cumenge in the *Comptes Rendus de l'Académie des Sciences* Vol. 128, p. 532 (1899), and in the *Bulletin de la Société Minéralogique française*, Vol. 22, p. 26 (1899).





Up the rocky trails, into the mountain fastnesses of Colorado, climb trains of patient burros, to return laden with carnotite, the principal ore from which radium is derived

far extracted in the United States has been used on watch faces, or on signs, etc., principally during the war, and that only from 80 to 90 grams have been available for physicians and in hospitals. In Europe the depletion of the radium supply was proportionately as great as in the United States. In view of this it is regarded as probable that the world's stock of radium does not exceed 100 grams. Although in weight this is equivalent to only 3.53 ounces, the value of this quantity of radium is \$10,000,000. By way of contrast, gold worth \$10,000,000 would weigh 14.8 tons. The ratio of value is, therefore, as 1 to 150,426.

Dr. Hamilton Phillips, Professor of Mineralogy, Princeton University, obtained the first American carnotite ore in 1902, separating the first radium of strength in December, 1902. This ore was then sent to Stephen T. Lockwood, of Buffalo, who formed the Welch-Loffturanium and Rare Metals Company, and this company separated radium in 1903.

The quantities of radium thus obtained are now in the United States National Museum.

Radium was first produced in this country from carnotite ore on a commercial scale in 1913 by the Standard Chemical Company of Pittsburgh. Since then several other companies have been formed to extract the precious metal. The gram of radium presented to Madame Curie by the women of America was supplied by the above-named company,<sup>1</sup> which had produced up to June, 1921, 74 grams of radium element.

The exhibit included photographs and explanatory labels supplied by the company, describing the process required to produce Madame Curie's gram of radium from the time the ore was taken out of the mines to the delivery of the finished product. Briefly, the process is as follows: the carnotite ore is mined together with a great deal of worthless rock. It is sorted by hand, sacked, and hauled down to the roads by burros. Then it is taken to the concentration mill and is considerably reduced in bulk before being shipped to the extraction plant. Here the carnotite ore is treated with chemicals to remove all barium and radium salts. The ore concentrate contains about ten parts per billion of radium and about one-half per cent of barium salt. The solution of radium and barium is treated with sulphates to precipitate an insoluble raw sulphate of radium, one ton of the material containing about one gram of radium. From this about one thousand pounds of pure barium-radium chloride are obtained. No single chemical operation is capable of removing the tiny quantity of radium from the huge amount of accompanying barium salt. From this point on, the purification process consists of fractional crystallization as first used by Madame Curie. Finally, a tiny pinch of nearly pure radium

<sup>1</sup>The mahogany box containing the gram of radium was designed by this company. It is one inch thick, and the case within has a lead lining  $1\frac{1}{4}$  inches thick, nevertheless 5 per cent of the gamma rays penetrate the walls. The radium was hermetically sealed in ten glass tubes of one-tenth gram each.



bromide is obtained which at first resembles powdered sugar. On standing in a sealed tube the salt acquires a brownish color and loses some of the bluish phosphorescent glow.

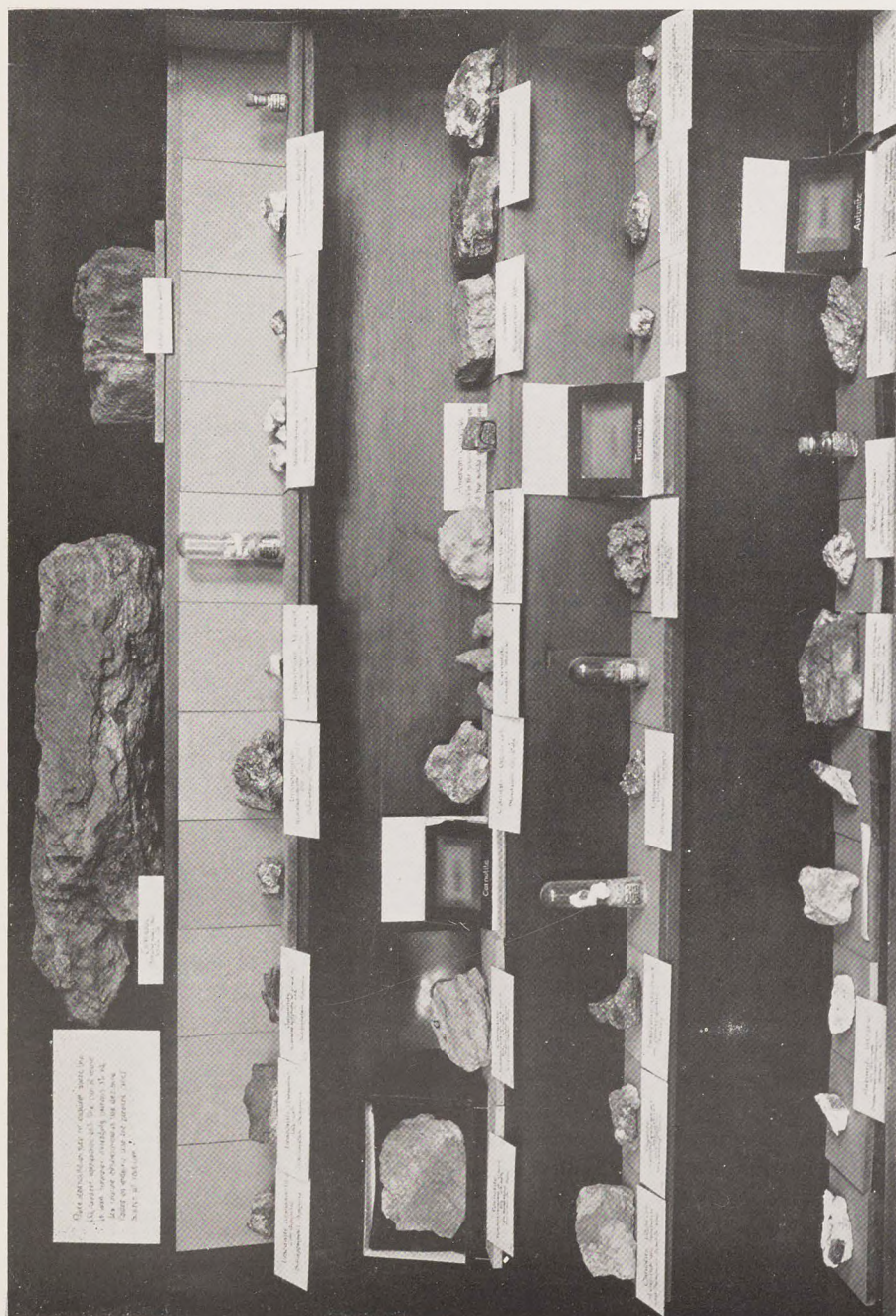
It is rather remarkable that the process of purifying radium today is essentially the same as the one used by Madame Curie when she discovered this new element. But the additional difficulties overcome in the commercial extraction of radium from carnotite ore are not to be minimized. An idea of the magnitude of the process can be formed from the following figures: to produce the barium-radium chloride containing one gram of radium it takes 500 tons of milling ore, 500 tons of chemicals, the power from 1000 tons of coal, 10,000 tons of purified and distilled water, and the labor of 150 men for one month. In addition, the process of fractional crystallization, which is carried out by expert chemists, requires five weeks' time. The final measurements of the amount of radium extracted are made about four weeks after it has been sealed in glass tubes, for it takes thirty days for the activity of the sealed radium to reach its maximum value. Before the radium is sold it is shipped to the United States Bureau of Standards, Washington, D. C., where it is re-measured and a certificate of its activity is issued. From the time that the ore is mined to the final measurement of the radium more than six months elapse.

On account of the laborious process of extraction, radium is the most expensive substance known. One gram of radium costs \$100,000, one gram of diamond \$3,000, one gram of platinum \$2.41, and one gram of gold \$0.66½. By reason of its scarcity and its high cost, the practical applications of radium at the present time are limited. During the war it was used rather extensively in the manufacture of luminous materials for gun sights, dials of nautical instruments, etc. Now only a small part of the total production is used in luminous materials. The employment of radium for this purpose is in

deference to its property of causing some substances to emit fluorescent light. Phosphorescent zinc sulphide, when mixed with a tiny quantity of radium, will emit a characteristic greenish yellow light for many years. This is the substance used on watch dials. Radium has also the property of changing the color of many substances when allowed to remain in proximity to them for some time. In the exhibit were included many minerals which had been affected by radium, showing the change of color produced by irradiation for a longer or shorter period. This subject has been studied very carefully by Dr. Cornelius Doelter, of Vienna, and he has found that minerals of the same species, but from different localities, acted differently in relation to the change of color. In his opinion a change of color by the radiation is only caused in such minerals as owe their natural color to the presence of a pigment, and among these it is necessary to establish a distinction between those which are colored by isomorphic admixtures and those which are colored by colloid pigments. In the former case the coloring is stable, and therefore, whether by heating or irradiation there is little change in color; those of the latter class, however, which owe their coloring to an unstable pigment, are easily changed in color by radium rays, and also by the Roentgen rays and ultra-violet light.

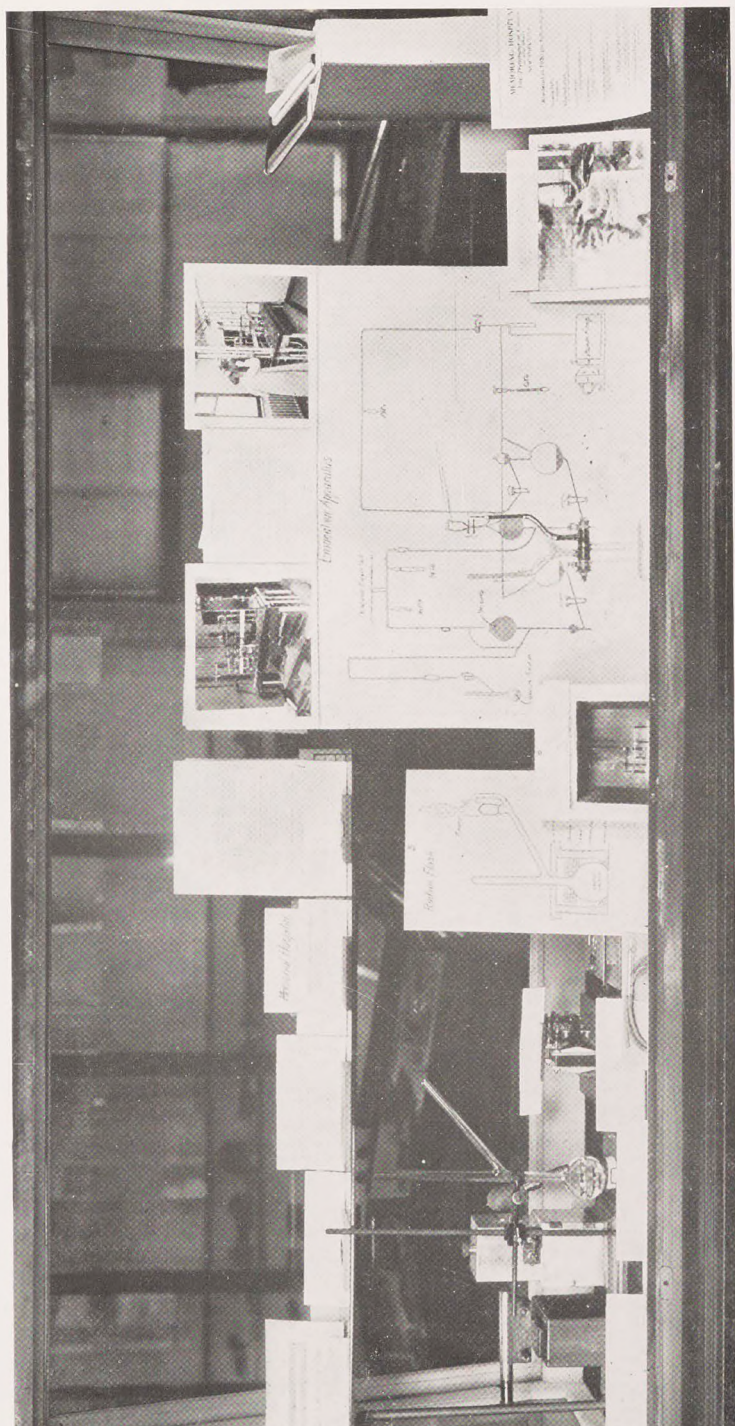
As to the rapidity of the color change, Dr. Doelter found, as might be assumed, that this depended upon the strength of the radium preparation employed. In his own work he used the exceptionally large quantity of 1½ grams of radium chloride. With smaller quantities a similar color change took place, but somewhat more slowly. To establish a series illustrating the rapidity of change, he took as a standard the intensity of the coloration after a definite period of exposure, and this gave him the series: Kunzite, halite, sapphire, fluorite, topaz, jacinth, quartz. Employing a different test, that of the first appearance of a





## RADIUM MINERALS



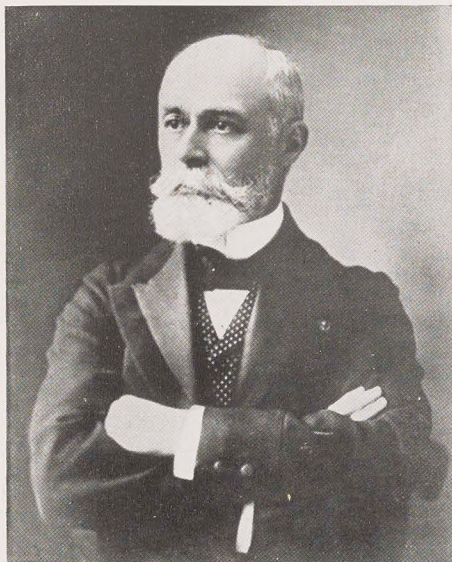


#### THE USE OF RADIUM IN HOSPITALS

This shows a section of the exhibit installed by the Memorial Hospital of New York City to explain the various devices required to make radium applicable in the treatment of disease. Some of the elements of this exhibit, shown here in miniature, are seen in enlargement in the subsequent pages of the article



change of color, the experimenter found that, in the examples he tried, halite from Wieliczka was the mineral which exhibited the earliest change of color; then came fluorite from Cumberland, followed



Henri Becquerel, who, as the discoverer in 1896 of radioactivity, paved the way for the discovery two years later of radium itself. In recognition of his eminent service to science he was in 1903 awarded the Nobel Prize jointly with Pierre Curie

successively by a Brazilian topaz, a barite from Cumberland, a sapphire from Ceylon, a Kunzite, and lastly a quartz from Maderanertal.

The first radium the Museum of Natural History owned was presented in 1903 by Dr. Edward Dean Adams, who subsequently also presented to that institution the splendid series of pictures showing phases in the eclipse of the sun; this radium was utilized by Dr. G. F. Kunz, in collaboration with Dr. Charles Baskerville, for the study of phenomena of phosphorescence in minerals.<sup>1</sup>

The largest and most valuable consignment of radium that has ever been moved at one time was lately brought to London from the Joachimsthal region in Czechoslovakia by Professor Soddy, of

<sup>1</sup>G. F. Kunz and Charles Baskerville, *Science*, 1903, p. 769.

Oxford University. This consignment consists of two grams of the precious substance, and is the first shipment made under the business arrangement recently arrived at between the Imperial and Foreign Corporation of London and the government of Czechoslovakia. It was deposited for safe-keeping at the Foreign Office. This radium, valued at £70,000 (about \$260,000 at the present rate of exchange) is loaned to England for fifteen years by Czechoslovakia for purposes of scientific research.

The most important application of radium is in medicine. At the present time nearly all the radium produced is devoted to therapeutic purposes. It is of happy augury that this wonderful new element should be dedicated to the alleviation of human suffering—the highest purpose for which it could possibly be used. It is a remarkable coincidence that Henri Becquerel, who discovered the property of radioactivity accidentally, should have found out also by chance that radium affects living tissue. Soon after the discovery of radium by the Curies, Becquerel carried about with him in his vest pocket a small amount of the precious salt enclosed in a glass tube, so that he might show the new substance to his friends. Some time later a burn developed in the skin directly under the pocket in which the radium had been. This, taken in conjunction with similar effects which had been observed, led to the use of radium radiations for the treatment of cancer.



Photograph taken through 15 cm. of lead by means of radium, showing the great penetrability of the gamma rays of this wonderful substance



The remarkable properties of radium are due to its radioactivity. In all other respects it behaves like a chemical element and is closely related to the metal barium. While, however, it may be said to be an element, it has the property of transmuting itself into an entirely different element, which in turn also disintegrates. The complete transformation series is shown in the following table:

| ELEMENT               | RADIATION<br>EMITTED | HALF VALUE<br>PERIOD |
|-----------------------|----------------------|----------------------|
| Radium                | alpha                | 1730 years           |
| Radium emanation      | alpha                | 3.85 days            |
| Radium A              | alpha                | 3 minutes            |
| Radium B              | beta + gamma         | 26.7 minutes         |
| Radium C              | beta + gamma         | 19.5 minutes         |
| Radium C'             | alpha                | 0.000001 second      |
| Radium D (Radio-lead) | slow beta            | 15.83 years          |
| Radium E              | beta + gamma         | 48.5 days            |
| Radium F (Polonium)   | alpha                | 136 days             |
| Lead                  |                      |                      |

Each change is accompanied by the emission of energy in the form of radiation, of which there are three distinct types designated alpha, beta, gamma. The alpha rays are positive particles of electricity traveling at very high speed, which become helium atoms when they collect two negative particles of electricity, or electrons, each. The beta rays are electrons traveling at still higher speeds than the alpha particles. Some beta particles have nearly the velocity of light, which is 186,000 miles a second. The gamma rays, like X-rays, consist of electromagnetic waves, in which they are identical with light, but their wave length is very much shorter than that of light and even shorter than that of X-rays. The alpha rays are very easily absorbed by matter,  $\frac{1}{10}$  mm. of glass being sufficient to stop them. The beta rays are much more penetrating, some being capable of traversing 2 mm. of lead. Finally, the gamma rays are extremely penetrating, for their presence can be detected even through 25 cm. of lead. The radiant energy emitted by radium has been measured: it is 133 calories an hour. Therefore a given amount of radium can melt its own weight of ice in less than three-quarters of an hour, and it is capable of doing this indefinitely.



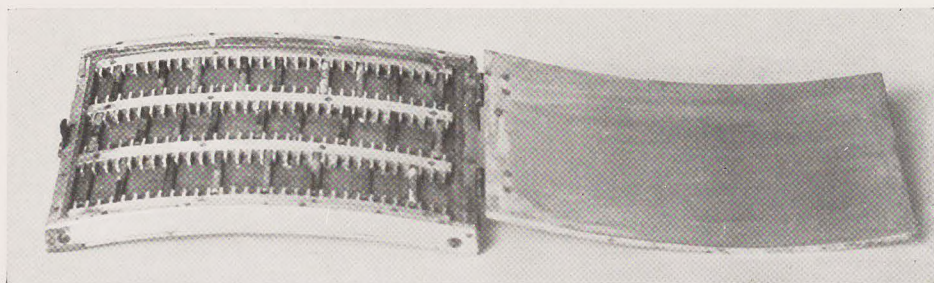
Courtesy of the "Scientific American"

Monsieur and Madame Curie, to whose genius and devoted labors the world is indebted for one of the greatest discoveries of all time

The energy which one gram of radium liberates during its life is 2,900,000,000 calories, while the energy produced by burning 1 gram of coal is 8000 calories. It is very important to remember, however, that radium gives off its energy at a very slow rate, which cannot be altered by any means at our disposal, while coal can be burned rapidly or slowly at will. Furthermore, the burning of coal is a chemical reaction in which carbon and oxygen combine to form carbon dioxide, while the emission of energy by radium results from the transformation of the radium atoms themselves into different atoms. The process of disintegration of radium proceeds at such a slow rate that it has been calculated that after nearly 2000 years there will still remain half of the initial amount. Yet the radiation emitted is so powerful that it is able to bring about marked changes in many substances.

When radium is employed for therapeutic purposes, it is not used as a drug. The physiological effect which it is capable of producing is due to its radiation and therefore it is not even necessary to bring it into intimate contact with the diseased tissue. Radium produces its effect at a distance by means of the invisible





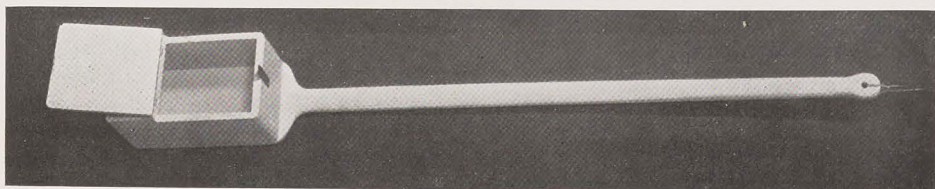
Radium applicator used for the treatment of deep-seated tumors. It is always applied at a distance of several centimeters from the skin. Only the very penetrating gamma rays are utilized in such cases. They pass through 2 mm. of brass before reaching the patient

rays which it emits. Of course, the closer it is to the tissue, the greater will be the effect, just as the closer we are to a lamp, the more light we receive. Of the three types of radiation which radium sends out, ordinarily only the beta and gamma rays are available for treatments. The alpha rays, being very easily absorbed by matter, cannot force their way through the walls of the radium containers and in any case they could not affect an appreciable thickness of tissue. Both beta and gamma rays can be resorted to when the diseased tissue extends to the surface, but only the very penetrating gamma rays can be used to influence a deep-seated growth without irreparable injury to the skin. In this case the radium is enclosed in a metal container of sufficient wall-thickness to absorb the beta rays. The metal acts as a "filter" through which the penetrating gamma rays pass substantially without loss, while the beta rays are completely absorbed.

There are two ways in which radium is employed for the treatment of patients: (1) the radium salt—usually the sulphate—is kept in sealed containers (tubes, hollow needles, etc.,) which are applied

to the patients; (2) the radium, in the form of bromide or chloride, is dissolved in water and the gas emanation, which results from its disintegration, is collected in small glass tubes, which are then used for treatments. On account of the complicated apparatus necessary for the collection and measurement of the emanation, this method is used only when relatively large quantities of radium are available. It has, however, many advantages, as it is inherently more flexible and has a wider range of application. All large institutions using radium have adopted this method.

In the exhibit at the American Museum both methods were represented. Dr. Robert Abbe, of New York, who was one of the first physicians to use radium in this country, contributed to the exhibition some applicators in which the radium tubes are placed for different treatments. He supplied also a number of casts showing different cancerous growths in their natural sizes and colors before radium treatment and the subsequent results. These casts indicated very strikingly the healing power of radium. In some cases the growth had disappeared



Box used for carrying radium applicators from one part of the Memorial Hospital to another. Note the long handle, a protective device to keep the holder out of proximity with the radium



without leaving even a scar. In Dr. Abbe's collection there were also many objects of historical interest, such as a tube containing some of the first radium brought to this country, a spinthariscopes, an electroscope used by the Curies, and the first quartz piezo-electric measuring instrument made by Professor Curie. This was later bestowed upon the College of Physicians of Philadelphia by Dr. Abbe, the formal presentation being made by Madame Curie on the occasion of her visit to that city.

The Memorial Hospital of the City of New York prepared a large exhibit illus-

When the work was first started at the Memorial Hospital in 1914 with a small amount of radium, the available knowledge of the effect of radiation on cancer was very limited. It was necessary, therefore, to develop a rational technique and the concomitant armamentarium. Steady progress was made in the methods of application at the same time that the supply of radium increased at the rate of 100 milligrams a month. Today the Memorial Hospital stands as the leading institution for radium therapy.

The four grams of radium are kept in a lead-lined steel safe, within a fireproof

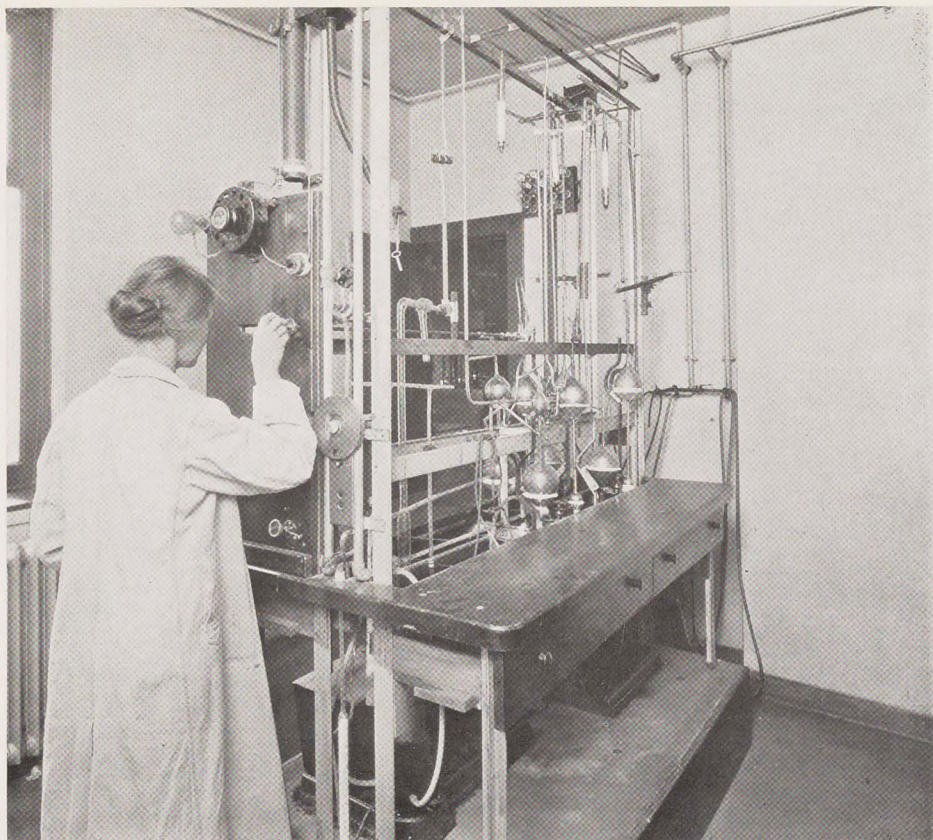


Applicators for irregular growths. They are made of dental modeling compound, and the emanation tubes are distributed evenly over the surface to be treated

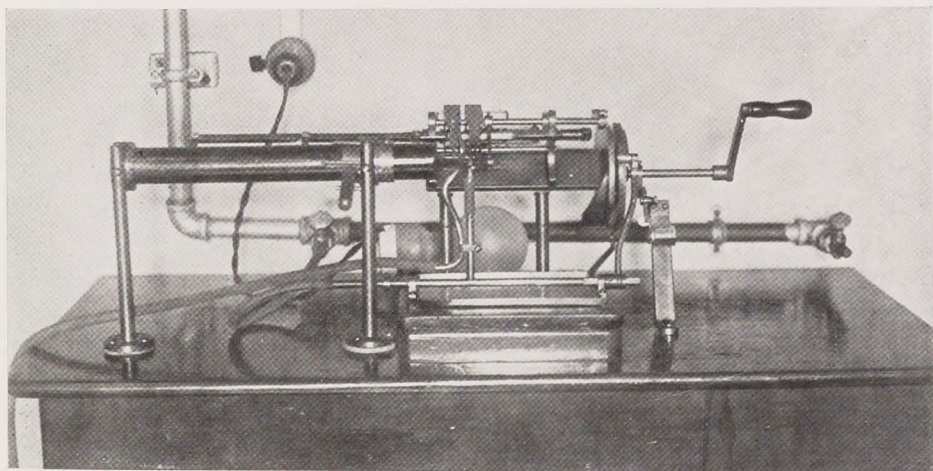
trating all phases of the radium work from the collection of the emanation to its use for therapeutic purposes. This institution is devoted solely to the treatment of cancer and allied diseases and has made an extensive study of the cancer problem. Radium is one of the most successful agents which the Memorial Hospital staff has adopted to combat cancer. It is gratifying to know that through the enthusiasm and generosity of the late Dr. James Douglas, a former Trustee of the American Museum, the Memorial Hospital has in its possession the largest quantity of radium of any public institution, namely, four grams.

vault. Four small glass flasks containing the radium in solution are joined to one glass tube, which in turn is connected with the intricate glass apparatus used for the collection of the gas emanation produced by radium. The apparatus is exhausted thoroughly by means of a vacuum pump and is kept as free of air as possible. On account of the decomposition of water under the influence of the radium rays, a very large amount of gas is mixed with the minute quantity of emanation which is to be collected in tiny capillary glass tubes. It is necessary, therefore, to separate the emanation from the "impurities." This is accomplished





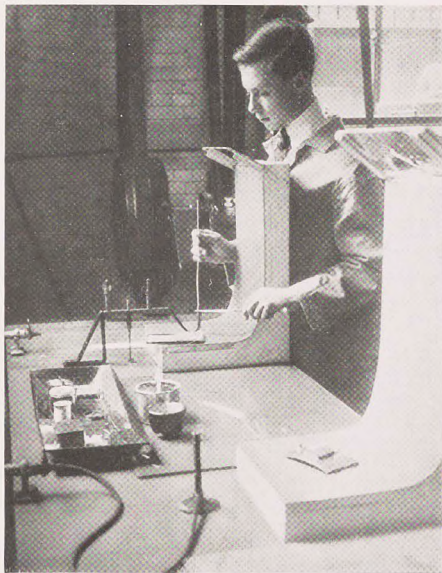
This intricate apparatus is used at the Memorial Hospital for the purification and collection of radium emanation. Note that the operator stands in front of a lead screen which protects her from the rays emitted by the (invisible) radioactive material at the other end of the apparatus. The remote control attachment here shown is necessary only when the emanation from a large amount of radium is to be collected. During 1920, there were collected with this apparatus, 200,000 millicuries of emanation



This machine was made at the Memorial Hospital to divide a long glass capillary tube containing radium emanation into a large number of tiny tubes. By turning the crank, the tubes are sealed off one by one. During 1920, this machine made 20,000 of these tiny tubes

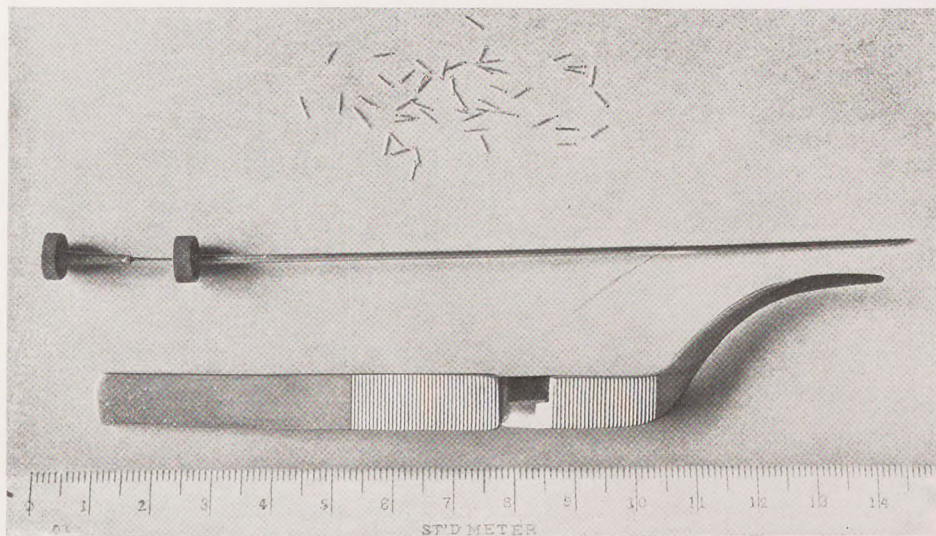


by chemical means, the gases being transferred from one part of the apparatus to another by means of suitable mercury pumps. Finally the emanation is forced into a capillary tube about the size of an ordinary pin and is sealed off by fusing the glass tube with a tiny gas flame. This tube is then divided into two or three parts and each is placed in a silver container. The latter can be used in the same manner that tubes containing radium salts are used. The beta and gamma rays, needed for treatments, being emitted only by Radium B and C, are identical in the two cases. The only difference is that the radiation from radium tubes remains practically constant in value while that from emanation tubes decreases in intensity at a fairly rapid rate. The amount of emanation in a tube is expressed in millicuries, a unit adopted in honor of Madame Curie. The gamma radiation from one millicurie of emanation is the same as that emitted by one milligram of radium element. If we have a tube containing 100 millicuries of emanation, the amount will have decreased to 83.5 mc. in 24 hours, to 69 mc. in two days, to 50 mc.



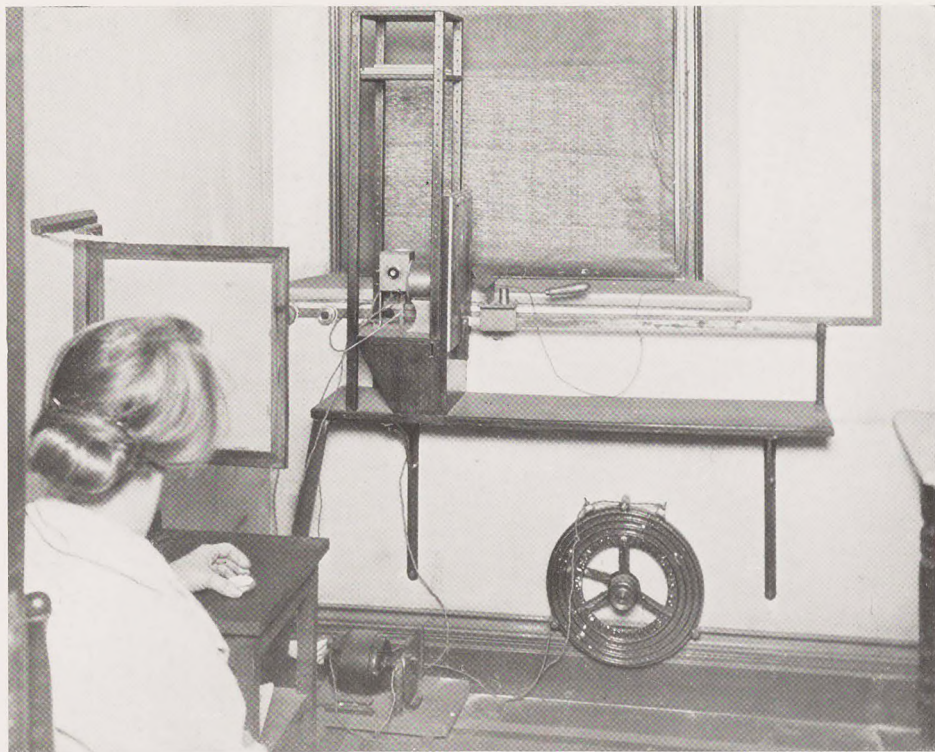
Technician at the Memorial Hospital preparing a radium applicator. Note the thick lead-lined, cast-iron protector, and the long forceps used for handling the tubes

in 3.85 days, to 25 mc. in 7.7 days, and so on. In other words, the amount of emanation decreases at the rate of 16.5 per cent in 24 hours. For this reason, when the emanation method is used,



The tiny glass tubes containing radium emanation are inserted into cancerous growths by means of a hollow steel needle and plunger. The tube is placed into the needle by means of the forceps shown and is then discharged into the diseased tissue. No attempt is made to recover the glass tubes, for they become "extinct" after two or three weeks





This instrument, a gold leaf electroscope, is used at the Memorial Hospital for the accurate measurement of radium. The image of the gold leaf is projected on a screen at a distance of three feet and the rapidity of its motion is determined with a stop watch. The radium or emanation to be measured is placed on the shelf or in the v-shaped support on the iron rail. The rays go through three-fourths of an inch of lead before reaching the electroscope proper and discharging the leaf. Other conditions being the same, the faster the leaf is discharged the larger the quantity of radium present

there is always available a supply of tubes of various strengths. Furthermore, the tubes can be made of different values initially.

A method of application which is not possible when radium salts are used, consists in the insertion in a tumor of tiny glass tubes containing about one milligram of emanation. The tubes are buried in the tissue by means of a hollow needle with a plunger and are left in place indefinitely. After two or three weeks their activity is practically negligible and as foreign bodies they are harmless. By this time, however, the tumor has been affected by the radiation. This method of treatment, which has been found to be very effective, has been developed to its present efficient state

at the Memorial Hospital. A large number of tubes is used in this manner every day. Their preparation made necessary the construction of a special machine which cuts the tubes rapidly, thus decreasing to a negligible amount the exposure of the workers.

The success of a treatment depends to a considerable extent on the administration of a proper dose of radiation. Therefore it is necessary, in the first place, to know the strength of each tube of emanation. The weight and the volume of the gas are extremely small and it would be impracticable to base the measurements on either. Advantage is taken, however, of the electrical properties of the radiation and electrical measuring instruments are used. A gold leaf electroscope is very

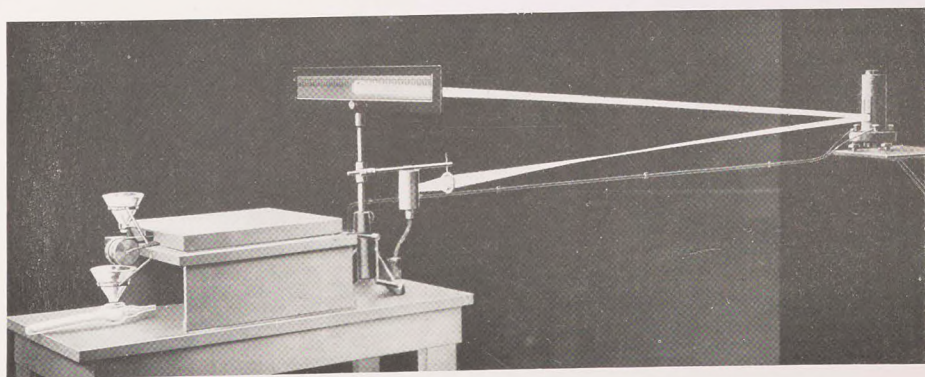


convenient for this purpose. The leaf is charged so that it stands out from its support. The radioactive material placed at a distance from the electroscope "ionizes" the air, that is, makes it a conductor of electricity, and consequently the charge from the leaf is carried away. The leaf then falls back to its initial position at a rate depending on the amount of radium or emanation in the specimen being tested. By measuring with a stop watch the time it takes the leaf to travel between two fixed points, it is possible to calculate the amount of radioactive material in the specimen. In practice the motion of the leaf is observed either with a microscope or by projecting it on a ground-glass screen. Ordinarily, the rays used to affect the air in the instrument pass through two centimeters of lead. Special electroscopes have been constructed capable of measuring  $\frac{1}{50,000,000,000}$  gram or  $\frac{1}{1,300,000,000,000}$  ounce of radium.

When a great many tubes have to be measured in one day, it is impracticable to use an electroscope. A convenient measuring instrument for more rapid determinations consists of a very sensitive galvanometer which measures the electrical current produced by the emanation in a suitable ionization chamber. This is the method used in measuring the

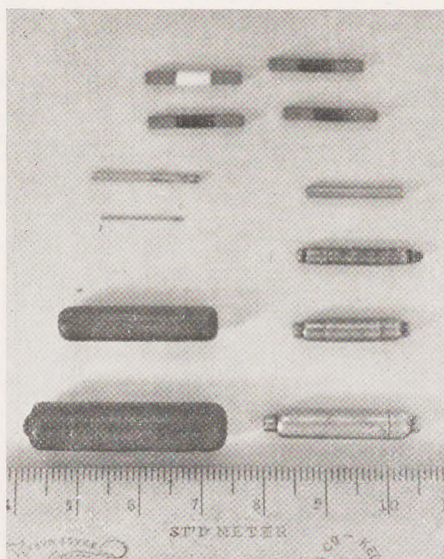
tiny tubes which are later inserted in tumors. These tubes are so small that it is quite difficult to handle them. The apparatus, therefore, is so constructed that each tube is picked up with long forceps only once in the process of measurement. An idea of their size can be obtained from the fact that 30,000 of them weigh only one ounce. The total amount of radioactive emanation they would ordinarily contain weighs only 0.00018 of a gram or 0.000006 of an ounce.

Of great importance is the protection of radium workers from the radiations. This problem has been considered carefully at the Memorial Hospital, where it is particularly important on account of the large amount of emanation to be handled, and safety measures have been adopted from the inception of the work. The tubes are handled always with 30-cm. forceps. Applicators are prepared behind lead-lined, cast-iron blocks, especially designed to protect the most vulnerable parts of the body. The emanation apparatus is so constructed that the operator stands behind a lead plate at a considerable distance from the active part. Measuring instruments have been designed with the same end in view. It should be remembered that it is not dangerous to be in proximity to

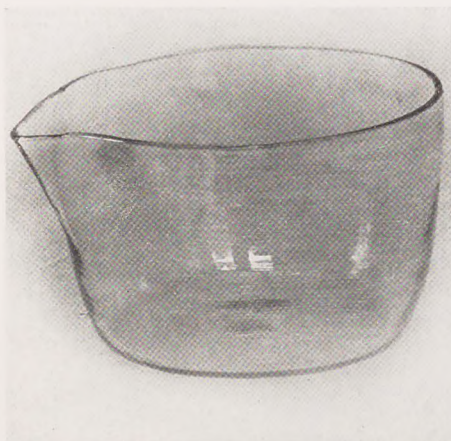


Instrument used to measure the radioactivity of "bare tubes." A very sensitive galvanometer measures the electric current produced in the ionization chamber by the rays. The beam of light serves as the pointer for the galvanometer. The tube to be measured is dropped through the upper funnel into a small box on a silk ribbon which carries it in the chamber when the crank is turned. The beam of light then is deflected according to the strength of the tube





Radium emanation containers. The smallest one is the glass tube in which the emanation is sealed. It can be placed into any one of the metal tubes shown. The latter serve the purpose of "filters," allowing some of the rays to go through and absorbing the others. They are made of platinum, lead, silver, or aluminum, according to the exigencies of the treatment



The receptacle in which Madame Curie's radium was handled just before it was ready for the glass tubes in which it was delivered to her. (The photograph shows exact size of receptacle.)

After 150 men had worked more than one month with over 500 tons of ore and 10,000 tons of distilled water, 1000 tons of coal and 500 tons of chemicals, they had a quantity of radium that just thinly covered the bottom of this dish

even a large amount of radium for a short time, or to be near a sufficiently weak source for a long time. Also the emanation, as soon as it is collected, is inactive, for the penetrating rays are emitted by Radium B and C, which accumulate gradually for three hours. These facts form the basis of the protective measures taken. The effect of a strong source can be decreased as much as we please by surrounding it with a sufficient thickness of matter, usually lead. The greatest trouble is experienced in making new technicians avail themselves of the protective devices provided. This is due to the fact that no immediate effect results from overexposure to radium rays. It takes usually more than a week for a visible effect to develop and sometimes even four or five weeks. If radium burned like an incandescent body, the problem of protection would be very simple.

A word should be said about the difficulties of radium therapy. In spite of the large amount of work done in this field, the present knowledge of the effects of radiation on cancer is more or less rudimentary. The main difficulty is that very little is known about the biological action of radiation. The necessary information cannot be obtained from the treatment of patients but must come from careful experimentation with the aid of the physical and biological sciences. Even now, however, radium is known to be of unquestionable benefit to several definite groups of patients for whom there was practically no hope of recovery or even improvement before the advent of radium. It is certain that through the efforts of such institutions as the Memorial Hospital of New York City, the Huntington Hospital of Boston, and others, the field of usefulness of radium in the treatment of this terrible disease will be greatly enlarged. The late Dr. James Douglas fully realized the importance of the experimental research in the development of radium therapy, for, in addition to the radium previously



mentioned, he donated to the Memorial Hospital a well-equipped laboratory building.

Space does not permit the description of the many pieces of apparatus and the instruments of the Memorial Hospital exhibit. An idea of the amount of work this institution is doing in the field of radium therapy may be gathered from the following figures: In 1920, 1656 new patients were treated, 2224 new and old patients were admitted to hospital beds, 28,525 days of treatment were given to these patients, 23,400 visits were made to the hospital by old patients for examination and advice, about 35 per cent of the above days of treatment were given without cost to the patient. From the radium in solution 200,000 millicuries of emanation were collected, 20,000 capillary tubes were made and measured, and 2672 radium applicators were prepared for the treatment of patients.

In conclusion, a few words may be said

about the place of radium in the treatment of cancer. The following statement is taken from the Memorial Hospital exhibit: it has been proved that radium is a reliable agent for the cure of accessible cancers in their early stages. It is of great value as a palliative agent in advanced forms of the disease. At present it cannot control widely extensive cancers. Therefore, the importance of the early recognition of this disease is emphasized more than ever.

During October a week was named "Cancer Week." A convention of surgeons and others held meetings in the course of which cancer and the application of radium were discussed. Some surgeons claim that no cures have been made with radium; others, that there have been cures. The general consensus of opinion seems to be that radium should be used only by physicians who themselves are thoroughly conversant with its properties and application.

THE AMERICAN MUSEUM OF NATURAL HISTORY



This is to certify that  
**Madame Marie Skłodowska Curie**

has been duly elected as

**Honorary Fellow**

of The American Museum of Natural History

Given under our hands and the seal of the Society in the City  
of New York the twentieth day of April 1921

*John S. Henshaw* President  
*Frank H. Taylor* Secretary

THE NEW YORK MINERALOGICAL CLUB  
BY UNANIMOUS VOTE OF ITS MEMBERS AT  
THE ANNUAL MEETING OF THE ORGANIZATION  
ON THE EVENING OF WEDNESDAY, APRIL THE  
TWENTIETH, 1921, AT THE AMERICAN MUSEUM  
OF NATURAL HISTORY, DESIRING TO EXPRESS  
ITS FULLEST APPRECIATION OF THE EMINENCE  
ATTAINED BY HER IN THE FIELD OF SCIENCE, AND  
HER TRANSCENDENT SERVICE TO HUMANITY  
THROUGH THE DISCOVERY OF RADIUM IN THE  
YEAR 1898, AND HER MANY AND GREAT CONTRI-  
BUTIONS TO THE SCIENCE OF RADIO-ACTIVITY  
HEREBY CONFERS UPON

MADAME  
MARIE SKŁODOWSKA  
CURIE

HONORARY MEMBERSHIP, WITH LIFE TENURE OF  
ALL THE RIGHTS AND PRIVILEGES PERTAINING  
THERE TO

*Willard Van Nostrand* PRESIDENT  
CORRESPONDING SECRETARY  
*Robert P. Watson* RECORDING SECRETARY  
*Leo C. Schuch* VICE-PRESIDENT

*Marie Perle Curie*

During her recent visit to America, Madame Curie was the recipient of distinctions from the foremost institutions of learning in the land. The American Museum conferred Honorary Fellowship upon her and the New York Mineralogical Club made her an Honorary Member



















